APPENDIX G

ANALYSIS OF ACCIDENT IMPACTS TO HUMANS

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APPENDIX G

ANALYSIS OF ACCIDENT IMPACTS TO HUMANS

An analysis has been performed to evaluate the potential consequences and risks of accidents affecting the polychlorinated biphenyl (PCB), low level radioactive waste (LLW), Mixed LLW, and transuranic (TRU) wastes currently stored at the Paducah Gaseous Diffusion Plant (PGDP). As previously discussed, two waste disposition options are being considered:

- **Proposed Action (Treatment and Disposal Alternative)** – All wastes are to be treated and disposed over a 10-year period. In this option, wastes may be disposed of on-site following on-site treatment if required or shipped off-site for treatment and/or disposal following on-site treatment if required. In either case, at the end of the 10 year period the risk due to on-site accidents is eliminated

- **No Action Alternative** – The wastes are to be packaged and stored on-site for an indefinite period of time. For purposes of this analysis, a 100-year institutional period of control is assumed. During this period, the stored wastes would be inspected and deteriorated waste packages replaced as required.

For each of these alternatives, accidents are postulated and the consequences and risks evaluated. The types of accidents considered include natural phenomena, process accidents such as vehicle impacts and dropped waste packages, and industrial accidents. Consequences include radiological exposure, toxic chemical exposure, and industrial hazards leading to injuries and fatalities.

The methodology, waste characterization, and the analysis of accidents affecting the two alternatives are discussed in the following sections.

G.1 METHODOLOGY

The estimated accident consequences were based on the inventories and material characteristics of the wastes stored on the PGDP site. Methods used to evaluate the significance of the potential adverse effects from postulated accidents are listed below.

- Estimated the frequencies of potential accidents occurring for the two alternatives.

  — “anticipated” accidents have a frequency of greater than 1 in 100 per year ($>1 \times 10^{-2}$ per year);

  — “unlikely” accidents have a frequency ranging between 1 in 100 to 1 in 10,000 per year (1×10^{-2} to 1×10^{-4} per year); and

  — “extremely unlikely” accidents have a frequency ranging between 1 in 10,000 to 1 in 1,000,000 per year (1×10^{-4} to 1×10^{-6} per year). Accidents having estimated frequencies less than 1×10^{-6} per year were not considered credible as evaluation basis events, and were not evaluated.

- Quantified the estimated amount of any release to the environment resulting from an accident.

- Quantified the radiological dose to a maximally exposed individual (MEI) at the PGDP boundary, 1580 m from the release, and the radiological doses to the surrounding public populations within 50 miles of the site due to the releases.

- Evaluated the radiological effects of accidents on workers:

  — Quantified the inhalation doses to maximally exposed, non-involved workers at 100 m (or more) from the release point. For fire accidents, a plume rise of 50 feet or 15 m was assumed. Given an elevated release, the maximum ground level concentration and dose occur 500 m from the accident location.

- Qualitatively evaluated the accident effects on involved facility workers:

  — Administrative controls would be in place to protect workers.

  — Workers in process areas are expected to have appropriate breathing and other protective clothing and equipment. These workers are expected to evacuate the vicinity of an accident without important consequence.

  — Workers away from process activities are considered non-involved unless they are performing specific tasks with appropriate protective equipment.

  Based on these assumptions, the risk to involved workers is maintained acceptably low by the use of appropriate protective equipment and risk is not analyzed or discussed further.

- Determined the health consequences associated with the doses in terms of "Latent Cancer Fatalities" (LCF) for populations and probability of cancer fatalities for individuals that would result from the exposures and doses. Cancer fatality consequences to the affected populations were based on the fatal cancer incidence rates of 4×10^{-4} LCF per person-rem in the worker populations and 5×10^{-4} LCF per person-rem in the off-site public. These risk factors also were applied to MEI and maximally exposed non-involved worker doses. The product of the dose and the fatal cancer incident rate is an estimate of the probability the exposed individual would experience a cancer fatality.

- Evaluated the effects of released toxic metals and other materials based on the potential for exceeding the Emergency Response Planning Guideline – Level 2 (ERPG-2) concentration (or estimated equivalent). This concentration defines the threshold for irreversible health effects.

- The risks of industrial accidents in each treatment alternative are computed in terms of expected fatalities. These risks are computed directly from the estimated labor (person-hours) per labor category in each treatment alternative defined in Section 4.13, Socioeconomic Impacts, and U.S. Department of Energy (DOE) estimates of the injuries and fatalities per person-hour. The DOE fatality rate for operations is 3.4×10^{-3}/200,000 person-hours (DOE 1999a).

- Risk was measured as the average consequence that accounts for both the consequence and likelihood of an accident. For example, an accident with a low likelihood and high consequence can have the same risk as an accident with a high likelihood and low consequence. For the comparison of accidents affecting the No Action and the treatment alternative, the risk measure selected is total expected fatalities. This risk is computed as the product of the accident frequency, the time period in which the accident can occur, and the computed consequence. The risk is used to compare the expectation of fatalities for the no action and the treatment alternative on a consistent basis.

$$Risk = Total\ Expected\ Fatalities = \frac{Accidents}{Year} \times \frac{Years}{Alternative} \times \frac{Cancer\ fatalities}{Accident}$$

G.2 WASTE CHARACTERIZATION

The wastes stored on the PGDP site consist of PCB containing capacitors and transformers, LLW, Mixed LLW, and TRU waste. The packaged wastes (excluding the capacitors and transformers) include approximately 600 m^3 of liquids, 350 m^3 of solid combustible wastes, and 10,700 m^3 of non-combustible solid wastes.

In general, the waste streams contain a mixture of radioactive isotopes and toxic metals. To evaluate the health impacts of releasing these wastes, a basis for summing the effects of individual isotopes or toxic metals is needed. The basis selected is to define a quantity of a characteristic isotope or toxic metal having the same health impact as the mixture. The selected characteristic isotope is 2% enriched uranium. For each individual isotope, the equivalent uranium activity in Ci is computed as the isotope activity times the ratio of dose conversion factor (DCF) of the isotope to the DCF for 2% enriched uranium, 2.64×10^6 rem/Ci. The individual activities in equivalent curies of uranium (Ci U) can be summed. As shown in Table 1.1, there is a total of 7830 equivalent Ci U in the 11,700 m^3 of waste.

A similar computation is performed for the toxic metals in the mixed LLW streams. In these streams, the specific metal contaminants are identified. Based on process knowledge, the concentration of each contaminant is estimated to be 5000 ppm. Chromium is the selected characteristic metal. The equivalent mass of chromium producing the same toxic effect is computed for each metal as the mass of the specific metal in the waste stream times the ratio of the metal's ERPG-2 to the ERPG-2 concentration for chromium, 1.5 mg/m^3. Similar to the equivalent uranium, the equivalent masses of chromium can be summed. The ERPG-2 concentration was selected as the toxicity characteristic since it is the threshold concentration for irreversible health effects following a one-hour exposure. An estimate based on Table 1.1 shows that the 11,700 m^3 of site wastes contain 1.5×10^8 equivalent g Cr.

G.3 ACCIDENT EVALUATION FOR THE PROPOSED ACTION

In the Proposed Action, the wastes are stored pending on-site treatment, on-site disposal, or shipment off-site for treatment or disposal. The types of activities associated with these actions include storage of waste containers, mechanical handling of steel waste containers, and opening of waste containers under controlled conditions to allow treatment (e.g. solidification of liquids, grouting). The general approach to performing the analysis is to postulate accidents, associated with the expected activities that have the potential to breech the steel waste containers and release the contents. Once released, the accidents are postulated to suspend a fraction of the wastes the air or surface waters. The suspended wastes are then transported to individuals and populations. The dose consequences to these individuals and populations are evaluated assuming no mitigation (i.e., no evacuation or sheltering).

G.4 ACCIDENT SELECTION

The following accidents are postulated for evaluation:

- The earthquake, as shown in Table D.1, affects all stored containers. The evaluation-basis earthquake (EBE) is a major earthquake used to evaluate the PGDPaducah Site facilities. This earthquake has a surface ground acceleration judged capable of toppling stacked drums and possibly ST-90 containers. A fraction of these toppled containers is postulated to partially fail.

Table G.1. Accidents with the potential to breech waste containers

Accident	Wastes affected	Estimated frequency
Evaluation-basis earthquake	All (12,000 m^3)	10^{-2} to 10^{-4}/year
Large aircraft impact and fire	10% (1200 m^3)	Not credible
General aviation impact and fire	2 m^3	10^{-4} to 10^{-6}/year
Ground vehicle impact/mishandling	1 m^3	$>10^{-2}$/year
Ground vehicle impact and fire	1 m^3	10^{-2} to 10^{-4}/year

- The large aircraft impact accident, if it occurred, would affect a large number of containers. In addition to mechanical damage, the released fuel could ignite the combustible wastes. The likelihood, however, of a direct impact of a large aircraft into the stored wastes is extremely small and is judged not credible based on comparisons of the aircraft impact frequencies affecting the large Paducah Site buildings. Based on the extremely low likelihood of this accident and on the fact that the consequences are judged comparable to the much more likely EBE, the large aircraft accident is not considered further.

- In contrast to the large aircraft impact accident, general aviation (small aircraft) impacts are more likely. Although the number of boxes affected would be small with respect to the earthquake, the consequences might be notable if a container were affected that had high-radionuclide-concentration, combustible wastes. As shown in Table 1.1, however, the radionuclide and toxic metal concentrations in combustible wastes are negligible with respect to other constituents. The mechanical damage to other waste forms would be comparable to the more likely vehicle impact and mishandling accidents. Based on the limited source terms and the low probability of the event, general aviation impact accidents are not considered further.

- As in the case of the small aircraft impact, a ground vehicle accident could breech one or more containers and possibly initiate a fuel fire. In general, the effects of a fire are not notable for most waste packages and vehicle impacts. However, the impact and fire accident could be postulated to breech the nearly empty PCB-containing transformers. In addition, mechanical impact accidents could release a limited quantity of high-activity wastes with a higher frequency than the EBE, and they are analyzed for this reason.

In summary, three bounding accidents have been selected for the evaluation of the proposed action: an EBE, a vehicle impact/container mishandling accident, and a vehicle impact accident and fire affecting a PCB-containing transformer.

G.5 WASTE CHARACTERIZATION AND STORAGE CONFIGURATION

The transformers and capacitors provide containment for the PCB oils within them. The listed mass is of the entire set of transformers and capacitors including the steel containers and the contained PCB oil. Individual capacitors contain approximately 2 gal of PCB oil each. The transformers are drained but can contain a residual quantity of up to 10% of the 1500 gal PCB oil capacity

The waste stream volumes of packaged wastes are directly estimated quantities. The waste stream masses are based on an assumed average density of similar wastes, 1 g/cc for liquids and soft solids and 2 g/cc for all other solids. For each isotope in the waste stream, the total isotopic activity is computed as the product of the total waste stream mass and the mean isotopic activity density. This isotopic activity is then converted to an equivalent activity of uranium and summed over all isotopes in each waste stream.

Similarly, the mass of each listed toxic metal is computed based on the waste stream mass and an assumed concentration of 5000 ppm for each metal. The mass of each metal is converted to an equivalent mass of chromium for each metal and summed over each metal in the waste stream.

The transformers are large steel shell containing the PCB oil. No additional packaging is assumed. Packaged wastes would be stored in steel containers ranging from 55 gal drums to sea-land containers. However, since the larger containers are difficult to topple and breech, all packaged wastes are assumed conservatively to be contained in 55 gal drums and stacked two high in a square array.

Four drums are assumed to be mounted on 4 foot by 4 foot pallets in double rows and stacked two containers high. To permit access to each container, a 16 foot aisle is assumed between each double row. Assuming an approximately square array, an array 180 m by 180 m is required to store the assumed 56,600 drums.

Some wastes are expected to be treated on-site or shipped off-site prior to the completion of the Proposed Action. However, for purposes of this analysis, all wastes are assumed to be at risk of accidental release and dispersion over the entire 10-year processing period.

G.6 ANALYSIS OF THE EVALUATION BASIS EARTHQUAKE ACCIDENT

In the event of a major earthquake, the horizontal surface acceleration is assumed capable of creating differential movement between the top and bottom box layers resulting in drums being toppled into the aisles. It is assumed that 10% of the entire upper layer of drums (2800 boxes) topple and fail. The 10% estimate is based on an evaluation of stacked 55 gal drums during seismic events (Hand 1998).

G.6.1 Radiological Source Term Computations

The physical characteristics of the packaged wastes vary importantly. However, for purposes of this analysis it is assumed that 10% of the entire radionuclide activity in the failed drums containing solids is in the form of a powder. Of this amount, 10% is released from the drum upon drum failure and subject to suspension in the air. For failed drums containing liquids, 10% of the drum inventory is assumed immediately released and subject to suspension in the air and the remaining inventory leaks onto the ground. The radioactive materials are assumed released proportionally from all waste streams and are assumed released uniformly over the entire 180 m by 180 m storage area.

The released radionuclides are assumed transported in the air and by surface waters to individuals and populations. The airborne source term (AST) is computed as the fraction of the released material that remains suspended as a respirable aerosol. For fine powders dropped 3 m, this fraction is empirically determined to be 6×10^{-4}; for liquids, this fraction is 1×10^{-4} (DOE-HDBK-3010, 1994). Summarizing, the AST is computed as:

$$
\begin{aligned}
\mathrm{AST} = {} & (\text{Total solid isotopic activity}) \times 5\% \text{ Boxes Damaged} \times 1\% \text{ Released as powder} \\
& \times 6 \times 10^{-4} \text{ suspended in air} \\
& + (\text{Total liquid isotopic activity}) \times 5\% \text{ Boxes Damaged} \times 10\% \text{ Released} \\
& \times 1 \times 10^{-4} \text{ suspended in air} \\
& = 3 \times 10^{-7} \times (\text{Total solid isotopic activity}) + 5 \times 10^{-7} \times (\text{Total liquid activity}) \\
\mathrm{AST} = {} & 2.4 \times 10^{-3} \text{ Ci U}
\end{aligned}
$$

The surface water source term (LST) is computed similarly. In this case, it assumed that 100% of the released liquid radionuclides (i.e., that fraction not suspended as an aerosol) is transported to the Ohio River via the Little or Big Bayou creeks:

$$LST = (Total\ isotopic\ activity\ ) \times 5\%\ Boxes\ Damaged$$
$$= 8\ Ci\ U$$

G.6.2 Radiological Dose Computations

The doses resulting from the AST and LST are computed as the product of a dispersion factor, an ingestion/inhalation rate, and the corresponding DCFs for U. These doses are computed assuming no action is taken to protect individuals or populations from exposure to the transported radionuclides.

Airborne doses are computed for a maximally exposed involved or uninvolved worker [maximally exposed involved worker (MIW) or maximally exposed uninvolved worker (MUW) at the downwind edge of the storage area, a MEI 1580 m from the area, and the surrounding population of 500,000 persons living within 50 miles of PGDP.

For individual doses, the atmospheric dispersion factor, χ/Q, is computed for a 180 m × 180 m square area source at the distances indicated. Using this method, the waste activities are assumed to be uniformly distributed over the area. These area χ/Q values are computed using standard methods (Turner, 1969). The individual doses are computed using a breathing rate of 1.2 m^3/hour or 3.33×10^{-4} m^3/s and the assumption that the individual remains in place for the entire time the wastes are being suspended and transported.

Population doses are computed based on the population dose model used in the *PGDP Environmental Report for 1991.* During 1991,a total source term of 0.0032 Ci of U, ^{99}Tc, ^{239}Pu, ^{237}Np, and ^{230}Th was released to the atmosphere. This source term is equivalent to an activity of 0.0061 Ci U. The total dose to the 500,000 persons living within 50 miles of PGDP was computed to be 0.0039 person-rem. On average, the population dose is proportional to the source term. As such, the population dose due to the earthquake can be computed as the ratio of the earthquake source term to the 1991 source term times the 1991 population dose. This reduces to the earthquake source term (Ci U) times 0.64 person-rem/Ci U.

The airborne source term doses, consequences, and risks are computed below. As discussed in Section 4.1.11, Methodology, risk is computed as the product of the earthquake median frequency, 1×10^{-3}/yr, the consequence, LCF, and the 10 year period of operation.

MIW/MUW at edge of area:

χ/Q = 1.8×10^{-3} s/m^3 (based on F stability, 1 m/s atmospheric conditions)
Dose = AST × χ/Q × Breathing Rate × DCF
= 2.4×10^{-3} Ci U × 1.8×10^{-3} s/m^3 × 3.33×10^{-4} m^3/s × 2.64 10^6 rem/Ci U
= 3.8×10^{-3} rem or 3.8 mrem

MIW/MUW Consequence:

Consequence = Dose × Fatality rate
= 3.8×10^{-3} rem × 1 person × 4×10^{-4} LCF per person-rem
= 1.5×10^{-6} LCF

MIW/MUW Risk = 1.5×10^{-8} expected fatalities

MEI 1580 m from area:

$\chi/Q = 8.8 \times 10^{-5}\ s/m^3$ (based on F stability, 1 m/s atmospheric conditions)

Dose $= AST \times \chi/Q \times$ Breathing Rate $\times$ DCF

$= 2.4 \times 10^{-3}$ Ci U $\times 8.8 \times 10^{-5}\ s/m^3 \times 3.33 \times 10^{-4}\ m^3/s \times 2.64\ 10^6$ rem/Ci U

$= 1.9 \times 10^{-4}$ rem or 0.19 mrem

MEI Consequence:

Consequence = $\Delta o \sigma \varepsilon \times$ Fatality rate

$= 1.9 \times 10^{-4}$ rem $\times$ 1 person $\times 5 \times 10^{-4}$ LCF per person-rem

$= 9.5 \times 10^{-8}$ LCF

MEI Risk = 9.5×10^{-10} expected fatalities

Population:

Dose $= AST \times 0.64$ person-rem/Ci U

$= 2.4 \times 10^{-3}$ Ci U $\times$ 0.64 person-rem/Ci U

$= 1.5 \times 10^{-3}$ person-rem

Population Consequence:

Consequence = Dose$\times$Fatality rate

$= 1.5 \times 10^{-3}$ person-rem $\times 5 \times 10^{-4}$ LCF per person-rem

$= 7.5 \times 10^{-7}$ LCF

Population Risk = 7.5×10^{-9} expected fatalities

Doses resulting from the liquid source term are computed based on the LST and a surface water transport model. Based on the 1991 Environmental Report, neither the Big or Little Bayou Creeks or the Ohio River within 4 miles of PGDP are used as a drinking water source. Furthermore, the major local population centers, Paducah, KY and Metropolis, IL are upstream of PGDP. It is assumed that a MEI downstream on the Ohio consumes surface water at a rate of 2 L/day. Populations using the Ohio River downstream of PGDP as a drinking water source are not known. Downstream of the confluence with the Mississippi River, the massive dilution is assumed to eliminate important population doses.

The entire LST is assumed suspended and mixed in the Ohio River over a 24-hour period. The Flowrate of the Ohio River at Metropolis, Il is 191,000 ft^3/s or 4.7×10^{11} L/24 h [U.S. Geological Survey (USGS) 2000]. The MEI ingestion dose is computed as the product of LST, the dilution in the Ohio River, the consumption volume, and the ingestion DCF:

MEI Dose = 8 Ci U $\times (1/4.7 \times 10^{11}$ L/24 h$) \times 2$ L/24 h $\times 2.6\ 10^5$ rem/Ci

$= 9 \times 10^{-6}$ rem or 0.009 mrem

MEI Consequence = 9×10^{-6} rem $\times$ 1 person $\times 5 \times 10^{-4}$ LCF per person-rem

$= 4.5 \times 10^{-9}$ LCF

MEI Risk = 4.5×10^{-11} expected fatalities

This dose and consequence are considered negligible even if a small downstream population did consume the untreated, contaminated water over the 24-hour period at risk.

G.6.3 Toxic Metal Source Term and Dose

The toxic metal source term is computed similarly to the radiological source term. However, no toxic metals were identified in liquid waste streams. As estimated from Table 1.1, the total toxic metal mass is 1.49×10^8 g Cr.

$$
\begin{aligned}
AST &= (Total\ toxic\ metal\ mass) \times 5\%\ Boxes\ Damaged \times 1\%\ \mathrm{Re}leased\ as\ \ powder \\
&\quad \times 6 \times 10^{-4}\ suspended\ in\ air \\
&= 3 \times 10^{-7} \times (Total\ toxic\ metal\ mass) \\
AST &= 45\ g\ Cr
\end{aligned}
$$

Assuming an 1- hour exposure period, the MIW and MUW would be exposed to a toxic metal concentration of:

$$
\begin{aligned}
Concentration &= \frac{45\ g\ Cr}{3600\ s} \times \chi / Q = 1.24 \times 10^{-2}\ g\ Cr/s \times 1.8 \times 10^{-3}\ s/m^3 \\
&= 2.2 \times 10^{-5}\ g\ Cr/m^3\ \ or\ 0.02\ mg\ Cr/m^3
\end{aligned}
$$

This concentration is negligible with respect to the 1.5 mg/m^3 ERPG-2 concentration for chromium. Based on this calculation, toxic metals would not be considered further.

G.7 ANALYSIS OF THE VEHICLE IMPACT ACCIDENT

During the storage period, it assumed that vehicles, such as forklift trucks, are used to reposition waste containers occasionally. Impacts with drums resulting in breech are assumed to occur at a rate of 1 in 10 years. Given an impact of a vehicle into the stored waste drums, it is assumed that one or more drums are breached. For the wastes stored at PGDP, 87% of the activity occurs in the single drum of ThF_4 and an additional 4% occurs in the 24 drums of TRU waste. The risks of accidents involving these wastes bound the risks of other waste streams.

The frequency of accidents involving these particular wastes includes the overall accident frequency, 1/yr, and the conditional probability of striking the particular waste form given an impact. The conditional probability of striking 1 drum out of 56,000 is 1.8×10^{-5} and 4.3×10^{-4} for striking one of the 24 drums of TRU. Based on this, impact accidents involving the ThF_4 drum occurs with a frequency of 1.8×10^{-5}/yr in the 10^{-4} to 10^{-6}/yr Extremely Unlikely frequency range and those impacting TRU waste drums occur with a frequency of 4.3×10^{-4}/yr in the Unlikely frequency range.

The source term for the ThF_4 release accident is based on the configuration of a glass container, within a steel container, within the drum. Given the accident it is assumed that 1% of the 8 lb of ThF_4 powder is released and a 6×10^{-4} fraction is suspended as a respirable aerosol. The AST for this accident is 0.041 Ci U.

For the TRU waste accident, it is assumed that 4 drums of the 10 solid TRU waste drums are impacted. As in the earthquake accident, 10% of the waste is assumed to be powder and 10% of the contents of each impacted drum is released. The AST for the TRU release is 3.8×10^{-4} Ci U.

The doses resulting from the ThF_4 release are computed similarly to the earthquake. For a single drum release, however, a point source versus area model is used. The distance to the MEI is 1580 m and the distance to the MUW is 100 m. In both cases F stability, 1 m/s atmospheric conditions are assumed. The MIW is assumed to have adequate protective equipment to allow rapid evacuation to an upwind location with minimal exposure. The MIW dose is assumed bound by the MUW dose. The MUW, MEI and population doses and risks are computed below. Risks are computed based on the 1.8×10^{-5}/yr frequency and an 10-year operating period.

MUW 100 m from release:

χ/Q = 3×10^{-2} s/m^3 (based on F stability, 1 m/s atmospheric conditions)
Dose = AST × χ/Q × Breathing Rate×DCF
= 0.041 Ci U × 3×10^{-2} s/m^3 × 3.33×10^{-4} m^3/s × 2.64 10^6 rem/Ci U
= 1.1 rem

Consequence = 1.1 rem × 1 person × 4×10^{-4} LCF per person-rem
= 4.4×10^{-4} LCF

MUW Risk = 7.9×10^{-8} expected fatalities

MEI 1580 m from release:

χ/Q = 3.4×10^{-4} s/m^3 (based on F stability, 1 m/s atmospheric conditions)
Dose = AST × χ/Q×Breathing Rate×DCF
= 0.041 Ci U × 3.4×10^{-4} s/m^3 × 3.33×10^{-4} m^3/s × 2.64 10^6 rem/Ci U
= 1.2×10^{-2} rem or 12 mrem

Consequence = 1.2×10^{-2} rem × 1 person × 5×10^{-4} LCF per person-rem
= 6×10^{-6} LCF

MEI Risk = 1.1×10^{-9} expected fatalities

Population:

Dose = AST × 0.64 person-rem/Ci U
= 0.041 Ci U × 0.64 person-rem/Ci U
= 2.6×10^{-2} person-rem

Consequence = 2.6×10^{-2} person-rem × 5×10^{-4} LCF per person-rem
= 1.3×10^{-5} LCF

Population Risk = 2.3×10^{-9} expected fatalities

It is noted that the vehicle impact source term and consequence are a factor of 17 higher than those for the earthquake accident. This is due to the assumption that 5% of the drums are ruptured and would not necessarily include the ThF_4 drum. It is very likely that the very high activity concentration ThF_4

drum would not be stacked or otherwise placed in a vulnerable position. If it is assumed that the ThF_4 is damaged by the earthquake, the source term and consequence would be comparable to the impact accident source term and consequence. However, the frequency for this unique earthquake accident would decrease by a factor of 20 to the Extremely Unlikely category.

The doses resulting from the TRU release are computed using the same assumptions and χ/Q as the ThF_4 release. The MUW, MEI, and population doses and risks are computed below. The risks are based on a 4.3×10^{-4}/yr frequency and a 10-year operating period.

MUW 100 m from release:

Dose $= 3.8 \times 10^{-4}$ Ci U $\times 3 \times 10^{-2}$ s/m^3 $\times 3.33 \times 10^{-4}$ m^3/s $\times 2.64\ 10^6$ rem/Ci U
$= 0.01$ rem or 10 mrem

Consequence $= 0.01$ rem $\times$ 1 person $\times 4 \times 10^{-4}$ LCF per person-rem
$= 4.0 \times 10^{-6}$ LCF

MUW Risk = 1.7×10^{-8} expected fatalities

MEI 1580 m from release:

Dose $= 3.8 \times 10^{-4}$ Ci U $\times 3.4 \times 10^{-4}$ s/m^3 $\times 3.33 \times 10^{-4}$ m^3/s $\times 2.64\ 10^6$ rem/Ci U
$= 1.1 \times 10^{-4}$ rem or 0.11 mrem

Consequence $= 1.1 \times 10^{-4}$ rem $\times$ 1 person $\times 5 \times 10^{-4}$ LCF per person-rem
$= 5.5 \times 10^{-8}$ LCF

MEI Risk = 2.4×10^{-10} expected fatalities

Population:

Dose $= 3.8 \times 10^{-4}$ Ci U $\times$ 0.64 person-rem/Ci U
$= 2.4 \times 10^{-4}$ person-rem

Consequence $= 2.4 \times 10^{-4}$ person-rem $\times 5 \times 10^{-4}$ LCF per person-rem
$= 1.2 \times 10^{-7}$ LCF

Population Risk = 5.2×10^{-10} expected fatalities

G.8 ANALYSIS OF THE VEHICLE IMPACT AND FIRE ACCIDENT

An impact of a gasoline powered truck or large forklift vehicle with a drained electrical transformer is assumed. The transformer is assumed punctured, and 10% of the 145 gal residual PCB oil residual volume coating the internal surfaces is released. The mass of PCB (assumed to be 100% Aroclor 1254) is:

Mass PCB = 145 gal $\times$ 3785 cm^3/gal $\times$ 1.5 g/cm^3 $= 8.2 \times 10^5$ g

The accident is assumed to cause the release and ignition of the gasoline fuel which pyrolizes the released mass of PCB oil over an 1-hour period.

Two combustion products are formed. Essentially all of the chlorine (Aroclor 1254 is 54% Cl) is stripped and released as HCl. In addition, approximately 1% of the PCB forms a pyrolized mixture of PCB, dioxins, and furans. The toxicity of this substance, PCB-soot, has been independently characterized [Martin Marietta Energy Systems (MMES) 1994].

The masses of combustion products are:

Mass HCl $= 0.1 \times 8.2 \times 10^5$ g $\times 0.54 = 4.4 \times 10^4$ g HCl

Mass PCB-soot $= 0.1 \times 8.2 \times 10^5$ g $\times 0.01 = 8.2 \times 10^2$ g PCB-soot

The combustion of the PCB oil requires relatively large fire since PCBs are difficult to burn. The combustion products are assumed to rise to an elevation of 50 ft or 15 m before dispersing downwind. The maximum χ/Q for a 15 m elevated release, assuming F stability and 1 m/s conditions, is 5×10^{-4} occurring approximately 500m from the fire. The concentrations of these combustion products are:

$$C_{HCl} = \frac{4.4 \times 10^7 \ mg\ HCl}{3600\ s} \bullet 5 \times 10^{-4}\ s/m^3 = 6.1\ mg\ HCl/m^3$$

This concentration is 20% of the ERPG-2 concentration for HCl

$$C_{PCB-soot} = \frac{8.2 \times 10^5 \ mg\ PCB-soot}{3600} \bullet 5 \times 10^{-4}\ s/m^3$$
$$= 0.11\ mg\ PCB-soot/m^3$$

The no-observed-adverse-effect limit (NOAEL) for PCB-soot is 19 mg-min/m^3 or 0.3 mg/m^3 for 1 h. As indicated, the computed concentration is 37% of the NOAEL.

Based on these computed concentrations, the estimated health effects of PCB release accidents are small and recoverable for the MUW and negligible for the MEI 1580 m from the accident.

G.9 ACCIDENT EVALUATION FOR THE NO ACTION ALTERNATIVE AND COMPARISON OF RISKS TO THE PROPOSED ACTION

During the No Action Alternative, the packaged waste containers would be transported to an on-site location and stored. The containers would be inspected periodically to verity that the containers are intact and repaired if required. These containers would be subject to the same conditions as the stored containers in the Proposed Action. However, they would be at risk for a longer period of time.

The transformers are assumed to remain in place within the process buildings and not be subject to the risks of vehicle impacts and fires. In the event of an accident, the combustion products of fires would be held up in the buildings minimizing on-site and off-site consequences.

Similar to the Proposed Action, accidents are postulated with the potential to breech the steel containers of the stored wastes and release the contents. The waste characteristics and the accident consequence methodology are the same as discussed for the Proposed Action. The accident selection and analysis results are discussed in Section 4.2.11. The risks for both the Proposed Action and No Action Alternative are calculated and compared in Section 4.2.11.

G.9.1 Accident Selection and Analysis

The following accidents are selected for evaluation of the No Action Alternative based on the process discussed for the Proposed Action:

Accident	Wastes Affected	Estimated Frequency
Evaluation Basis Earthquake	all (12,000 m^3)	10^{-2} to 10^{-4}/year
Ground Vehicle Impact/Mishandling	1 m^3	$>10^{-2}$/year

As discussed above, the PCB containing transformers are assumed stored indoors and not subject to the hazards assumed in the Proposed Action. Since other packaged wastes do not have important radionuclide or toxic metal concentrations, fire accidents are not considered for the No Action Alternative.

In summary, two bounding accidents are selected for evaluation: an EBE and a vehicle impact/container mishandling accident. Since the waste characteristics and the accident scenarios are the same as those evaluated for the Proposed Alternative, the accident consequences are identical to those computed and discussed in Section 4.1.11. However, while the frequency of the earthquake accident is the same for both alternatives, the frequency of vehicle impact/mishandling accidents is much lower due to the lower activity level. It is estimated that vehicle impact/mishandling accidents occur with a frequency of 0.1/yr for the No Action Alternative versus 1/yr for the Proposed Action. The conditional probability of striking a particular drum or set of drums is the same as discussed for the Proposed Action: 1.8×10^{-5} for the ThF_4 drum and 4.3×10^{-4} for the TRU waste drums. The corresponding accident frequency for accidents involving these drums are, respectively, 1.8×10^{-6}/yr for the ThF_4 drum and 4.3×10^{-5}/yr for the TRU waste drums. The risks for the accidents occurring in the No Action Alternative are summarized below based on the revised accident frequencies and the 100-year institutional control period:

Earthquake:

MIW/MUW Risk = 1.5×10^{-7} expected fatalities
MEI Risk = 9.5×10^{-9} expected fatalities
Population Risk = 7.5×10^{-8} expected fatalities

Vehicle Impact/Mishandling-ThF_4 Container

MUW Risk = 7.9×10^{-8} expected fatalities
MEI Risk = 1.1×10^{-9} expected fatalities
Population Risk = 2.3×10^{-9} expected fatalities

Vehicle Impact/Mishandling-TRU Containers

MUW Risk = 1.7×10^{-8} expected fatalities
MEI Risk = 2.4×10^{-10} expected fatalities
Population Risk = 5.2×10^{-10} expected fatalities

As shown, the risks for the No Action Alternative increase for the earthquake by a factor of 10 due to the longer period at risk. However, the risks for the impact accidents remain the same due to the compensating longer risk period and lower annual frequencies. Similar to the risks for the Proposed Action, these risks are considered inimportant.

In contrast to the accident consequences affecting the waste packages, the consequences of industrial accidents are smaller on a yearly basis due to the smaller workforce required. During the No Action Alternative, it is assumed that the stored wastes are monitored for possible deterioration on a periodic basis. It is assumed that this activity requires 30 full-time employees or 60,000 person-hours/yr over the 100-year alternative duration. Based on the 3.4×10^{-3}/200,000 person-hours industrial fatality rate, 1.0×10^{-3} fatalities/yr. Over the 100-year duration of the No Action Alternative 0.1 fatalities are expected. This represents a factor of 5 increases in the risk over the Proposed Action due to the longer duration of No Action Alternative.

G.9.2 Comparison of Accident Risks

Risks have been computed for both process accidents and industrial accidents for the Proposed Action and the No Acton Alternatives. The highest radiological accident risk was 1.5×10^{-7} expected fatalities for the MIW/MUW at the edge of the waste storage area during and following an earthquake. This risk was computed for the 100 year No Action institutional period. The second highest risk, 7.9×10^{-8} expected fatalities, was computed for the Vehicle Impact/Mishandling accident impacting the ThF_4 Container during the 10 year Proposed Action operating period and during the 100 year No Action Alternative. The risks are the same for both alternatives due higher per year frequency but lower overall duration of the Proposed Action. These risks are inimportant.

The industrial accident risks, while higher than the radiological accident risks, were small. The computed risk for the Proposed Action was or 0.02 expected fatalities over the 10-year operating period. The corresponding industrial accident risk for the No Action Alternative was 0.1 expected fatalities over the 100-year institutional control period. Neither risk nor the difference between them is considered important.

G.10 REFERENCES

MMES (Martin Marietta Energy Systems, Inc.) 1994. *Guidance on Health Effects of Toxic Chemicals,* ES/CSET-20, Martin Marietta Energy Systems, Inc., Oak Ridge TN, February 1994.

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